CONCRETING in COLD WEATHER

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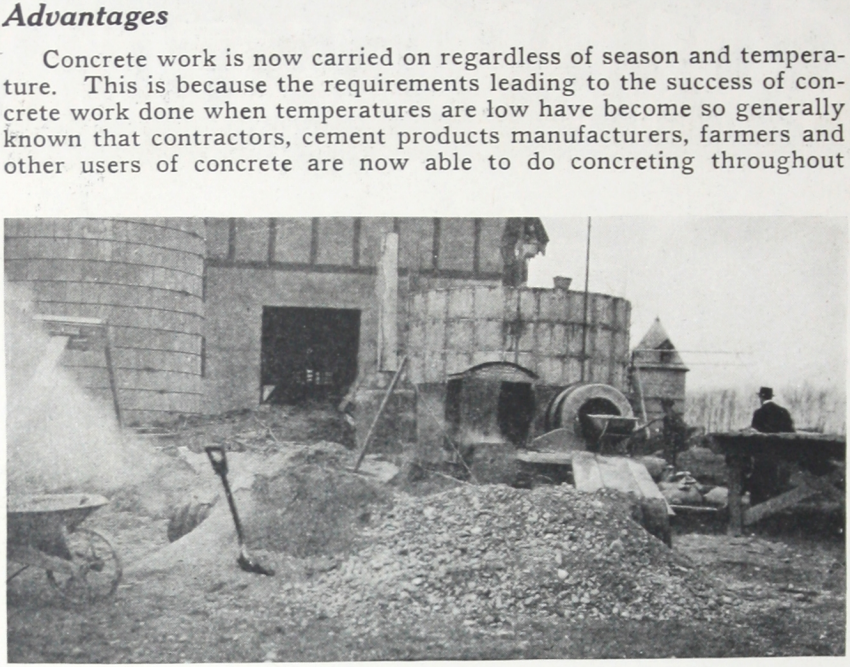
Concreting in Cold Weather

Advantages

Concrete work is now carried on regardless of season and temperature. This is because the requirements leading to the success of concrete work done when temperatures are low have become so generally known that contractors, cement products manufacturers, farmers and other users of concrete are now able to do concreting throughout



Monolithic concrete silo in process of construction during the winter at the North Dakota Agricultural College, Fargo, North Dakota. Aggregates being heated over section of old smokestack or metal culvert pipe

the year, thus finding profitable employment for time that might otherwise be idle.

By observing some simple and easily applied rules for preparing concrete mixtures, then using a few simple means to protect the freshly placed concrete, the resulting work will be just as successful as though carried on during warmer weather. The farmer can keep his farm hands busy during spare time in the winter, making concrete fence posts, concrete block, small concrete watering troughs and tanks, and laying barn and other interior concrete floors; thus his working capacity will be improved and his abilities as a producer of vital foodstuffs increased.

Many concrete products plants take advantage of opportunities to keep their plants working throughout the year. A little expenditure of time is often all that would be necessary to fix one of the plant buildings so that it could be made a comfortable workroom for carrying on the manufacture of a plant's specialty or specialties throughout the winter.

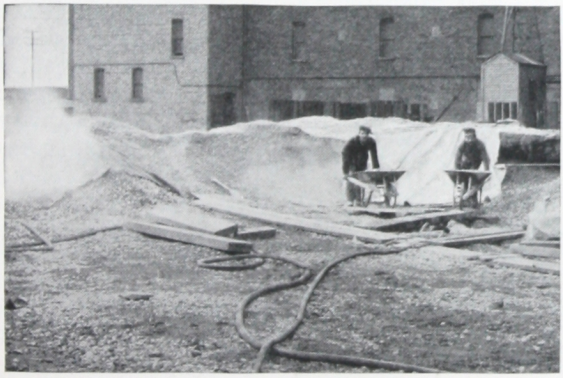
Concrete work done when the average temperature is below a certain point may cost a little more than the same kind of work done under the usual summer conditions. On the general run of contracting this cost seldom runs more than 10 per cent above that of work done in warm weather and frequently not more than 6 per cent—sometimes even less. Part of this extra expense comes from applying necessary protective measures, and part results from the lower efficiency of workmen through exposure to the cold. Some of the increased cost may be due to the added time necessary for the concrete to harden, which prevents such speedy progress of the work as would be possible in warm weather.

Pipe coils like this, laid over an open fire, can be used to heat water, flow being regulated so that water will heat while running through the coil

Contractors have found that prospective builders are usually willing to pay any slight extra cost of work done in cold weather to obtain the benefit of having their buildings completed and ready for use at an earlier date.

Effect of Low Temperatures on Concrete Work

Heat hastens the hardening of concrete; cold delays it. The effect of cold becomes noticeable in this respect when temperatures are below 50 degrees Fahrenheit, and becomes more marked with the lower temperatures.



Materials may be heated by thrusting steam pipes into them and covering the piles with canvas to retain the heat thus given

The general opinion is that freezing will not injure concrete that has first had an opportunity to harden for at least 48 hours under favorable conditions. If, before early hardening has taken place, concrete is allowed to freeze and thaw at short intervals, it will be damaged. As a rule, concrete will not show any serious effects from having once been frozen if, after it thaws out, it is not again frozen

until early hardening is complete. But it is far better to protect the concrete from freezing for from 48 hours to four or five days, depending upon the degree of the cold, rather than to expose it to the possibility of freezing. If such protection is given, no injury need be feared when the concrete is finally exposed to freezing temperatures.

Freshly placed concrete for roof of concrete silo, protected by canvas covering

Some of the requirements leading to success with concrete work done in cold weather are self-evident when one remembers the conditions under which concrete hardens and gains strength in warm weather. Warmth and moisture are necessary to the proper hardening of concrete. Any means that will cause both these conditions to be present, in cold weather, particularly during the period of early hardening, will lead to the success of concrete work done at such times, if every other good practice is also followed.

Heating Materials

If sand and pebbles or broken stone and mixing water are all heated, the concrete mixture will be so warmed that more rapid early hardening will take place. Heating the mixing water and neglecting the aggregates, however, is insufficient. Warmth given the concrete from heated materials can readily be held in it for some time—as long as may be necessary to complete early hardening—if the concrete is placed quickly after mixing and at once protected in some one or more of the several ways that will be described later.

Protecting newly laid concrete walk against possible freezing by applying a covering of hay or straw. This should be weighted down with pieces of short boards to prevent the covering from being blown away

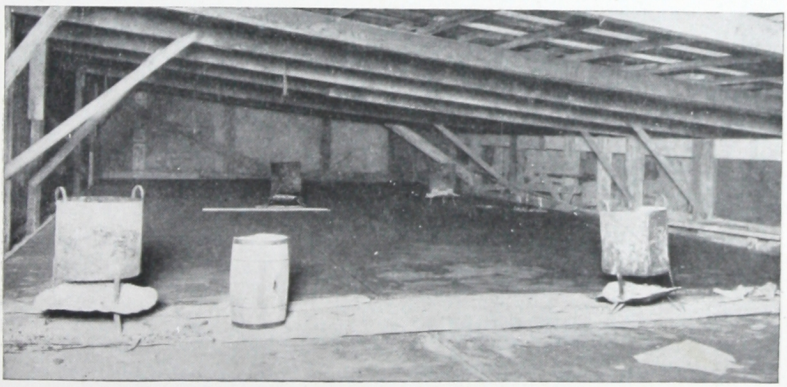
Additional heat is also developed in the concrete mass as a result of changes taking place from the chemical combination

of the cement and water. This also helps to keep up the temperature of the freshly placed concrete and thus aids to protect it from freezing. As cement forms only a relatively small bulk of a concrete mixture, it need not be heated, but it should be stored where it will be protected from dampness and extreme cold.

Work can be housed in by means of canvas tarpaulins and the enclosure kept at safe working temperature by salamanders

Heating Water

Mixing water is the easiest of the materials to heat. It can readily be heated to 150 degrees Fahrenheit, and kept at this temperature until used, by one of several methods. Two methods are in common use for heating mixing water; one is to use live or exhaust steam from a steam plant, and the other is to heat the water in tanks or kettles over a fire. On large contracting jobs mixing water is usually heated by steam. If a steam engine is used to run the

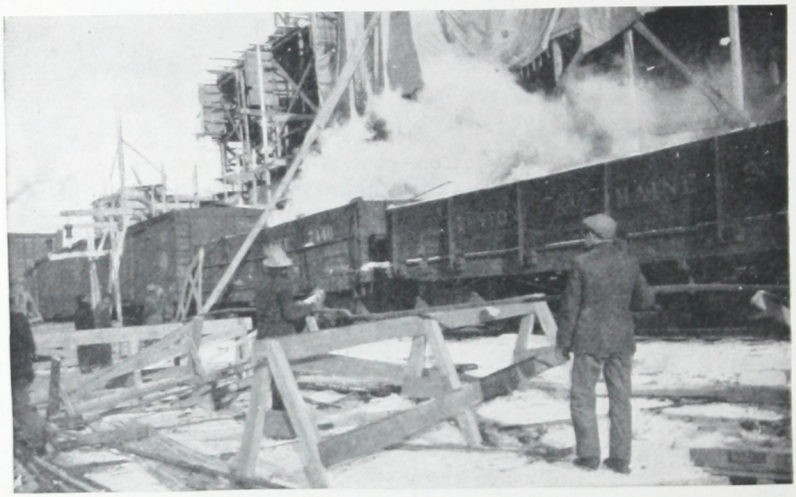


Concrete sidewalks in business sections have often been made during cold weather by housing in as here shown and keeping the enclosure at proper temperature by using salamanders

mixer, the exhaust steam is often allowed to discharge into a water tank that is a fixture on the mixer. This arrangement is satisfactory, but does not heat as rapidly as live steam.

Live steam, which is steam under pressure, furnishes more heat where considerable quantities of water are required at regular intervals. When live steam is used and the water has been heated as required, its temperature can readily be kept at the desired point by a regulating valve that will admit only enough steam to the water to keep it hot. An old steam boiler that is no longer safe for carrying high steam pressures may sometimes be used as a source of steam supply, since a boiler pressure of 25 pounds is sufficient for the purpose.

On small jobs a tank or large kettle supported above a fire may supply all the heated water that is needed. Coils of pipe similar to steam radiator coils have been supported above a fire and water allowed to flow slowly through the coils and into a barrel, the water being heated as it passed through the coils. In such a case also after the required amount of water has been heated, it can be kept at the desired temperature by allowing no more water to pass through the coil than can be converted into steam, this being discharged into the barrel.



Aggregates being heated by thrusting steam pipes into the material as received loaded on cars

Heating Sand and Pebbles or Broken Stone

Unless sand, pebbles and broken stone are stored indoors during the winter, they are certain to contain frost, and sometimes lumps of snow and ice. Frozen materials should not be used in concrete mixtures. They not only chill the concrete, but prevent thorough mixing. Sand and pebbles or broken stone should be heated. A temperature not exceeding 150 degrees Fahrenheit will generally prove sufficient. Too much heat will injure some kinds of sand and pebbles or broken stone, particularly limestone.

Complete protection afforded by enclosing the work by use of tarpaulins

On small jobs these materials are usually warmed by piling them over and around sheet iron cylinders, such as an old smokestack, a section of old iron sewer or culvert pipe, or an old steam boiler. A

"Working under summer conditions" on the concrete building of the Robertson-Cataract Electric Co., Buffalo, N. Y., February, 1916. Usually such complete methods of housing in are not required

fire is built within and the materials to be heated piled around and upon this "stove." Sometimes a stove is built by using concrete block for a foundation and covering with a piece of sheet steel such as boiler plate. It is necessary to turn or rake over the materials frequently so that those nearest the fire will not become too hot and thus possibly injured, while at the outside and edges of the pile they may not be warmed.

Separate stoves are best for heating sand and pebbles, although sometimes a pipe stove may be long enough so that sand can be piled at one end and pebbles or broken stone at the other. Care should be used

Open fire pots or salamanders like the one shown here are generally used to provide heat necessary to keep enclosures warm enough to prevent concrete from freezing

to keep the two materials separate, otherwise when taking them from the pile to proportion a batch of concrete, some batch is likely to be improperly proportioned because the sand and pebbles became mixed before measuring.

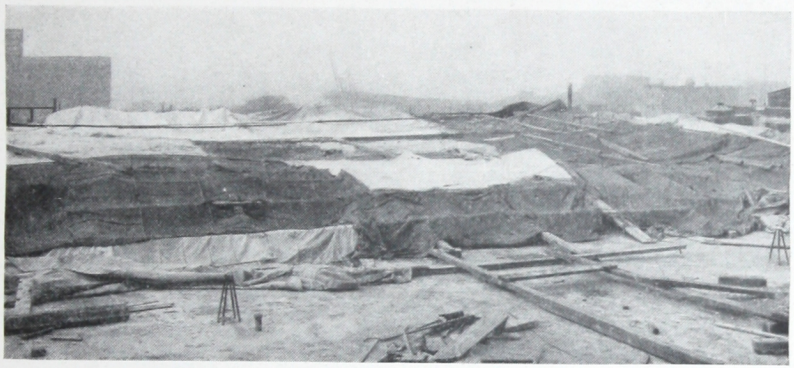
Heating sand and pebbles or broken stone by steam has advantages over other ways. They may be piled directly on steam-heated pipe coils or the piles may be covered with tarpaulins and steam applied directly to the materials. The tarpaulins act to house in the piles and thus to hold the heat. With a steady supply of steam this method of heating is quite effective. The pipes used are closed at one end and perforated along their lower side by numbers of very small holes. The other end of the pipe is connected to the source of steam supply by means of steam hose. The pipes are then stuck into the piles of materials and steam turned on.

While cold weather concreting is in progress, piles of sand and pebbles or broken stone exposed to the weather should be kept covered

with tarpaulins to prevent the materials from becoming water-soaked and possibly frozen solid if the temperature should drop suddenly.

Use of Salt in Mixing Water

Water containing common salt, calcium chloride (chloride of lime) and a number of other chemicals will not freeze at the same temperature as water which contains none of these substances. For this reason, it was common when concrete work was first done in cold weather, to add salt to the mixing water to prevent the concrete from freezing. As not more than 10 per cent of salt can safely be used without danger



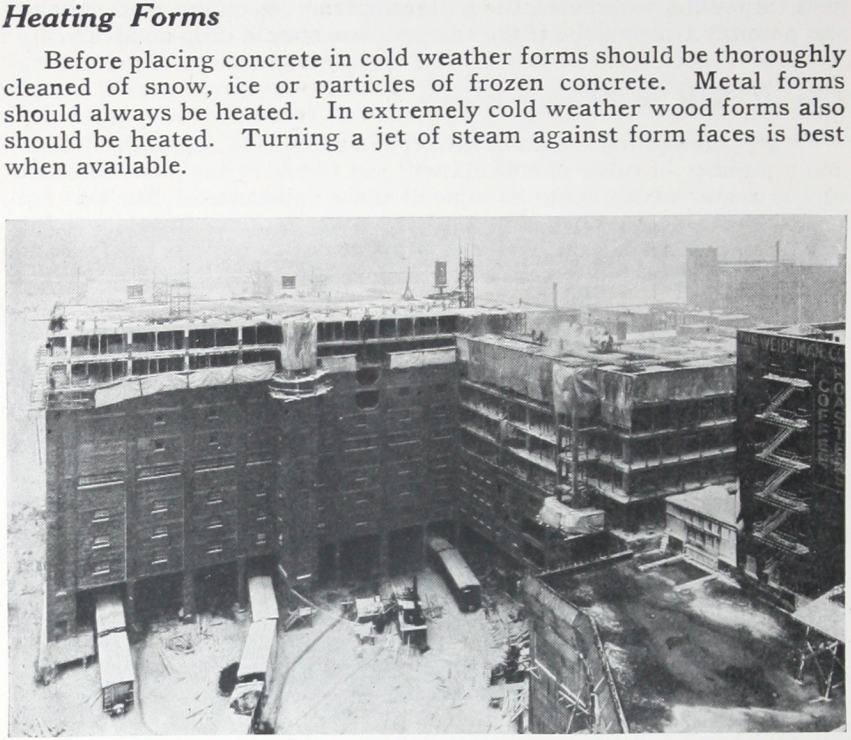
Newly laid floor housed in by building a scantling frame and covering with canvas. The enclosure is heated by salamanders kept burning beneath this covering

of affecting the final strength of the concrete and as such a quantity of salt gives protection only against a possible drop of temperature of 10 degrees below freezing, the use of salt is not effective when cold is extreme. Besides, salt does not accomplish the one thing most desirable. It delays instead of hastens the hardening of the concrete. Salt is considered objectionable in reinforced concrete because it may corrode the reinforcing steel. Salt should not be used where the appearance of the finished work would be spoiled by the whitish deposit that may later appear on the surface. This deposit is commonly referred to as efflorescence and may be expected on work in which salt has been used.

In general, calcium chloride (chloride of lime) is also objectionable for reasons similar to those mentioned for salt, although experiments conducted by the United States Bureau of Standards indicate that there may be a possible advantage in using it in some cases, because a 4 per cent solution in water seems to hasten the hardening of concrete. The use of calcium chloride is said to increase the cost of concrete work from 12 to 15 cents per cubic yard.

Heating Forms

Before placing concrete in cold weather forms should be thoroughly cleaned of snow, ice or particles of frozen concrete. Metal forms should always be heated. In extremely cold weather wood forms also should be heated. Turning a jet of steam against form faces is best when available.



Reinforced concrete construction on the West 9th Street terminal, Cleveland, Ohio, during the winter of 1916-17

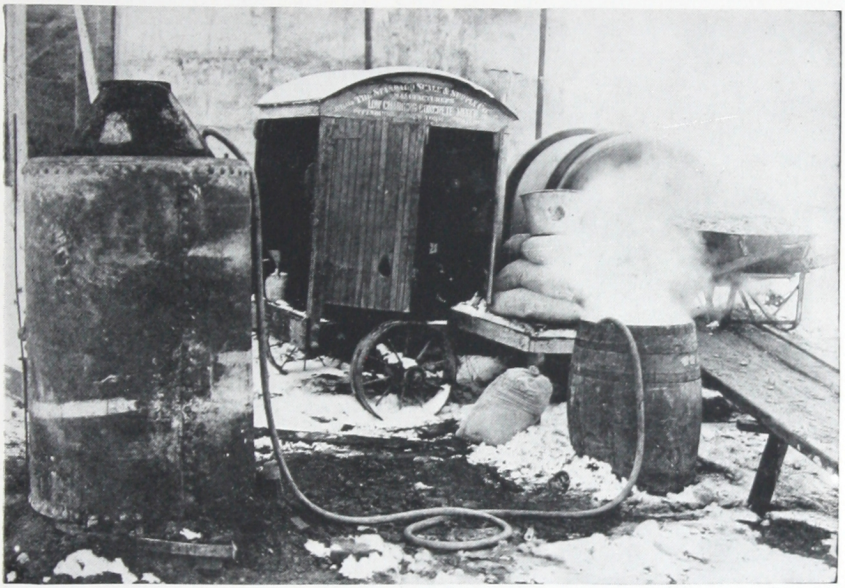
Protection to Be Given

In the following paragraphs a number of ways of protecting concrete work done in cold weather will be described. Usually no one of these methods or ways is used alone. Generally two or more of them are combined.

After forms have been cleaned of ice, snow and any particles of frozen concrete, and have been warmed, the concrete mixture should be placed immediately so that none of the warmth given to it by the heated materials will be lost. All of the work should be done as quickly as possible.

Thin floor slabs, beams, columns, sidewalks, feeding floors, barnyard pavements and similar classes of work have a large surface area compared with their volume; therefore, more careful protection must be given to such work than to foundations, abutments and other mass construction where the excavation or the bulk of the mass and heavy forms give part of the required protection. Floors are usually protected by a covering of hay or straw. Building paper or canvas should

first be laid over the concrete, then from 6 to 12 inches of straw, depending upon the temperature to be protected against. If the work is out of doors the covering should be weighted down with short boards to prevent it from being blown away. Sidewalks, feeding floors and road and street pavements must receive extra care. Sometimes walks in business districts are housed in by means of a canvas-covered frame and the enclosure kept warm by steam or open coke-burning stove pots, commonly spoken of as salamanders.



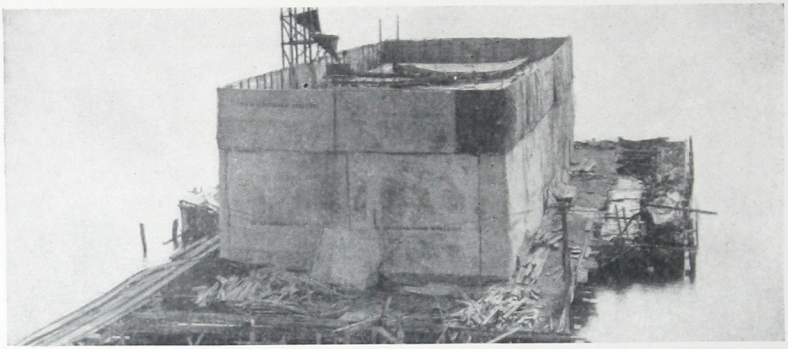
Sometimes an old steam boiler not safe for usual working pressures can be used to generate steam sufficient to warm mixing water on the job

When forms are tight and made of heavy material, mass work may require no other protection than covering the concrete exposed at the top. This protection can be given by a layer of hay or straw, while vertical faces may be given additional protection besides that given by the forms by building a rough lattice work of strips 10 or 12 inches from the outside face of forms and filling in between lattice and forms with straw or manure. Such extreme measures are usually required only when the cold is very severe.

If manure is used as a covering, it should never be placed directly upon the fresh concrete. It is not only likely to stain the work, but may injure the surface by causing a slight pitting or scaling. This is probably due to the fact that sometimes nitric acid is formed when the manure rots and this chemical is probably the substance that has caused injury to concrete surfaces protected by manure covering, in those cases observed in the past.

Foundations can easily be protected because the greater portion of the work is in an excavation. Forms, or earth walls of the trench give enough protection to the sides of the work if the cold is only moderate. There remains nothing but the top surface to be covered.

Barn and stable floors built during winter should be laid in such sections that a portion of the old floors may be used while concreting is in progress. This is necessary because of the longer time that concrete requires for hardening in cold weather to be safe for use.



Reinforced concrete fish packing building at Portland, Me., during the winter weather. Concrete work was made possible by observing all precautions described in this booklet and by housing in the work as shown with canvas

For such indoor work little additional protection is needed besides that given by the enclosing structure. Temperature may be kept as desired by oil stoves. Do not have a dry heat. Pans of water over salamanders or stoves will furnish sufficient moisture. Care should be taken, however, to prevent the possibility of fire. This also applies where salamanders or open coke-burning stoves are used to supply heat. It is a wise precaution always to have an attendant on the job as a measure of safety against the spread of fire.

Removing Forms

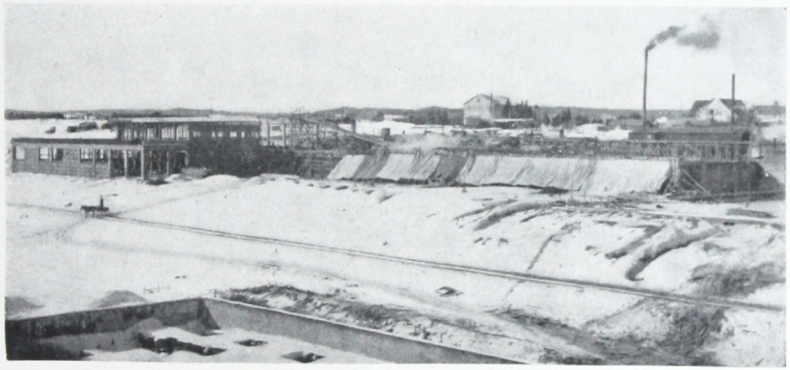
Although too early removal of forms is to be avoided regardless of season, this statement applies with great force to work done during cold weather. Especially is this true of concrete walls, roofs, and overhead floors which are intended to carry loads other than their own weight. Forms should be left in place until it is absolutely certain that the concrete has become strong enough to be safe. Frozen concrete often has the appearance of thoroughly hardened concrete. If struck with a hammer it will ring just like hardened concrete. The work should be examined carefully before forms are removed. A single section of the forms or part of a section may be removed to expose the concrete, then the flame from a plumber's blow torch, a jet of steam or hot water may be directed against the concrete surface.

If merely frozen the heat will thaw the water in the concrete, thus showing the condition of the work.

Cold Weather Concrete Work on the Farm

There is much concrete work on the farm that may be carried on during cold weather. Farm hands may thus be kept at work when they might otherwise be idle. Concrete block, fence posts, small watering and feeding troughs can be made indoors.

A convenient room for carrying on cold weather concrete work indoors can usually be arranged by fixing up some portion of a shed, barn or cellar. Sand and pebbles should be brought into the workroom and stored until desired for use. The workroom temperature should never be lower than 50 degrees Fahrenheit. If the materials are stored in such a temperature, frost or frozen lumps of material that may have been in them will disappear if the piles are well raked over occasionally. Materials containing frost or frozen lumps must not be used in concrete mixtures. If the workroom is not large enough



Concrete construction at Pabos, Quebec, carried on during severe winter weather. This work was housed in as it progressed, and usual precautions used to prevent freezing

to store a considerable quantity of materials and they must therefore be brought indoors as required for use, some means for heating them must be arranged.

Care must be taken to prevent concrete block, fence posts and similar products from freezing during the first two or three days after made. They should be stored for a long time before being used, preferably until spring.

Cold Weather Highway Work

It is sometimes necessary to complete a job of concrete street or road paving when temperatures may drop below freezing, and on such work caution should be taken to avoid any possibility of damage to the concrete by frost.

Concrete should not be placed on a frozen subgrade. Methods to be followed in combating the injurious effects of cold weather may be grouped under the following headings:

(a) Application of artificial heat to materials or finished work, and means of preventing the dissipation of heat developed during the setting of the cement. (Heating of water or aggregates; heating fresh concrete by steam lines; the use of covering, etc.)

(b) Use of chemical compounds which will lower freezing point of mixing water, or hasten setting of the cement.

Special care must be taken to avoid the use of lumps of frozen aggregate. This is generally called to attention in the specifications.

Framework used for supporting covering to protect concrete pavement laid during cold weather near Quantico, Va.

On account of the frequent moving of equipment, heating of aggregates is not always practicable in road work, although this can be done in other kinds of concrete construction.

If a source of steam supply is available, aggregate may be heated by inserting steam pipes carrying live steam into the piles. This heating will be greatly facilitated by covering the piles with canvas.

Desirable results can be obtained at little expense by heating the mixing water. This can best be accomplished by inserting an improvised steam coil in the water line near the mixer. The water coil may be heated by a wood or coal fire. It is not necessary that the water be extremely hot, as it will accomplish a useful purpose if this

method serves to remove only the chill from the aggregate and impart some heat to the fresh concrete. Satisfactory heaters for this purpose are on the market.

In the event of an extreme drop in temperature, pipe lines supplied with live steam may be carried under the canvas to protect the fresh concrete from freezing. If the concrete has partly hardened, protection may be provided by covering with straw.

A 1-inch layer of sawdust with a canvas overtop has been found very satisfactory where the temperature does not drop more than three or four degrees below freezing. Hay or straw used as a covering, with canvas on top, will serve the same purpose. It is important that where this is used the material be lightly forked onto the road so as to retain as much air as possible, which is the heat retaining medium.

Heating aggregates used in concrete road work done near Quantico, Va., during the winter of 1917-18

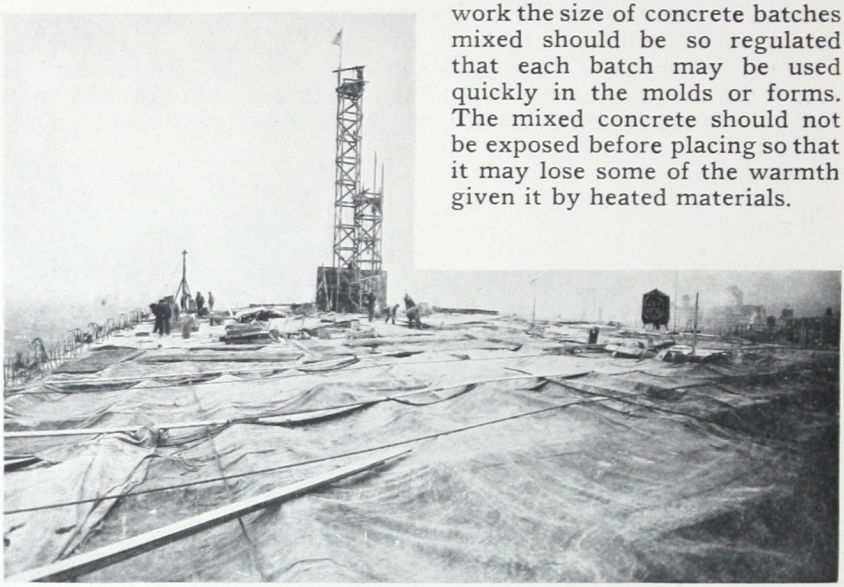
Cold Weather Concrete Work For Concrete Products Plants

In general, the recommendations already given for doing concrete work in cold weather apply to the manufacture of concrete products at commercial plants. Many such plants have buildings that do not permit the operation of the plant twelve months a year. In most cases they could be fixed up at little expense and the plant be profitably operated all the year.

Workrooms and hardening rooms or chambers should be so arranged that drafts of cold air will be prevented from striking the freshly-made concrete products. The workroom temperature should be kept above 50 degrees Fahrenheit.

Modern plants harden their concrete products by steam. This is a great advantage at any time of year, but particularly so in cold weather.

In all cold weather concrete work the size of concrete batches mixed should be so regulated that each batch may be used quickly in the molds or forms. The mixed concrete should not be exposed before placing so that it may lose some of the warmth given it by heated materials.



Construction view taken December 31, 1915, while cold weather concrete work was in progress on the building of the Sperry Gyroscope, New York. Turner Construction Co., New York, contractors

Of Interest to the Contractor

Concrete contractors who are prepared by experience and equipment to keep their forces employed during cold weather know the profits resulting from thus lengthening their working season. Their equipment is usually such that it is easy for them to apply the precautions that have been described in this booklet as necessary. One large construction company in the East makes cold weather concreting almost a specialty. This, however, should not cause contractors in general to look at this class of work as one in which they also should specialize. Long experience with cold weather concreting is necessary for success on large jobs.

The last edition of the Building Code Recommended by the National Board of Fire Underwriters, New York, devotes some space to measures that are recommended in connection with cold weather

concreting. Among other things, this code suggests that "when concrete has been deposited while the outside temperature was above 40 degrees Fahrenheit with a rising temperature," ample supports be left to carry the construction until it is undoubtedly safe to remove them. This code further recommends that "a special permit should be obtained for removal of forms from concrete deposited when the outside temperature was below 32 degrees Fahrenheit and the number of days required should be increased in proportion to the amount of time the temperature remained below 32 degrees Fahrenheit after the concrete was deposited."

An example of winter concrete work carried on by the Turner Construction Co., New York, showing protection to the interior of one story while the floor is being concreted

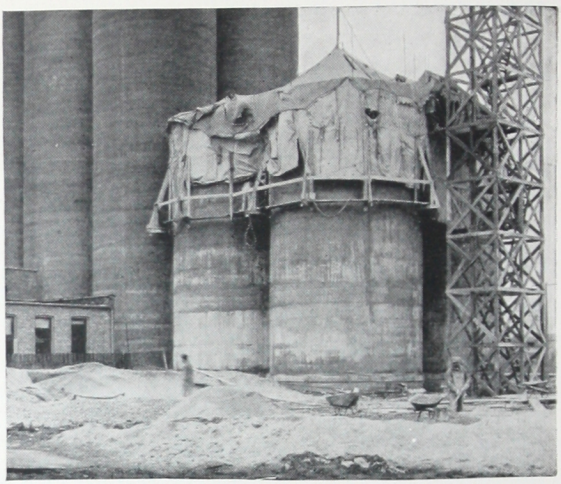
For the contractor not thoroughly experienced in cold weather concrete work it is recommended that, when the average temperature for the day is between a minimum of 40 and a maximum of 50 degrees Fahrenheit, the building in or on which work is being carried on should be enclosed. When the average temperature is below 40 degrees and above 35 degrees Fahrenheit, the materials should be heated. When the average temperature falls below 35 degrees Fahrenheit, the building should be heated by salamanders or similar means so that the interior temperature surrounding the concrete work will always be higher than 40 degrees.

Occasionally it is necessary for the contractor to make some provision on the job for the comfort of his workmen. Shelters or wind shields have been built around benches where carpenters were building forms, as well as around the concrete mixer to protect the men. Where excavating is going on in the open, it is best to have a small shanty with a good fire where the men can warm themselves occasionally. Other means of furnishing reasonable comfort for men working under unfavorable temperature conditions will suggest themselves to the experienced contractor.

Facts to Remember

REMEMBER that during the first few days following the placing of concrete, alternate freezing and thawing at comparatively short intervals will damage it.

REMEMBER that protecting the concrete against possibility of freezing is best, even though concrete which freezes before early hardening has been completed may not be permanently injured, if after thawing out it is not again exposed to freezing until hardened.



Concrete grain bins built during freezing weather by using canvas covering to retain heat given by salamanders kept burning inside the bins. On this particular job concrete was mixed by hand in structure beneath this protection

REMEMBER that it is necessary to so mix, place and protect the concrete that early hardening will be complete before the work is exposed to freezing temperatures.

REMEMBER that to do this:

(1) Sand and pebbles or broken stone used must be free from frost or lumps of frozen materials.

(2) If these materials contain frost or frozen lumps they must be thawed out before using.

(3) As cement forms but a relatively small bulk of the materials in any batch of concrete, it need not be heated.

(4) Mixing water should always be heated.

REMEMBER that although adding common salt to mixing water will prevent freezing of fresh concrete until it has had time to harden, there is a limit to the quantity of salt which may be added if the final strength of the concrete is not to be affected. Salt simply lowers the freezing point of the mixing water; it does not supply what is most

needed—heat and warmth. It delays, instead of hastens, the hardening of the concrete.

REMEMBER that sand and pebbles or broken stone and mixing water must be heated so that the concrete when placed shall have a temperature of from 75 to 80 degrees.

REMEMBER that some sands are injured by too much heat. The same applies to certain varieties of pebbles and broken stone. A temperature not exceeding 150 degrees Fahrenheit will generally prove most satisfactory.

REMEMBER to place concrete immediately after mixing so that none of the heat will be lost before placing in the forms.

REMEMBER to warm metal forms and reinforcing before placing concrete. Be careful to remove ice and snow and frozen concrete remaining on the forms from preceding work. Forms can be warmed by turning a jet of steam against them or by wetting with hot water.

REMEMBER that even though materials have been heated and the concrete placed immediately after mixing, it will lose much of its heat if not protected from low temperatures, at once.

REMEMBER, therefore, to protect the concrete immediately after placing. Canvas covering, sheathing, housing-in the work, or hay or straw properly applied will furnish the required protection for different jobs. In addition to these means, small oil or coke-burning stoves or salamanders may be used in enclosed structures. Guard against dry heat.

REMEMBER that temperatures which may not be low enough to freeze the concrete may, nevertheless, delay its hardening for a considerable time. Do not expect concrete placed when the temperature is low and remains low for some time afterward to be safe for use as soon as though placed during warmer weather.

REMEMBER that if concreting is unavoidably delayed or interrupted the work should be covered until concreting is again begun.

REMEMBER to cover and protect any section of the work as soon as completed. In severe cold weather, continue this protection for at least five days.

REMEMBER that forms must not be removed from the concrete work too early. This applies to any concrete work, regardless of season, but is particularly important with work done during cold weather.

REMEMBER that frozen concrete sometimes very closely resembles concrete that has thoroughly hardened. When frozen concrete is struck with a hammer it will often ring like properly hardened concrete. Before removing forms, examine the work carefully to see whether it has hardened or simply frozen. To determine this, remove one board from some section of a form, pour hot water on the concrete or turn the flame of a plumber's blow torch or a jet of steam under pressure against the concrete. If the concrete is frozen, the heat will soften it by thawing the water contained in it.

REMEMBER—SAFETY FIRST.